



TOOELE
ARMY
DEPOT

FINAL

PROJECT WORK PLAN

IMPLEMENTATION OF ALTERNATIVE MEASURES INDUSTRIAL WASTE LAGOON

TOOELE ARMY DEPOT TOOELE, UTAH

**Contract No. DACW05-00-D-0010
Task Order No. 7**

Prepared for:



U. S. Army Engineer District, Sacramento
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Sacramento, California 95814

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MAY 2003



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ACRONYMS AND ABBREVIATIONS

ASTM	American Standard Test Method
BRAC	Base Realignment and Closure
DSHW	Division of Solid and Hazardous Waste
EPA	U.S. Environmental Protection Agency
gpm	Gallons per minute
HEC	Hydrologic Engineering Center
hp	Horsepower
IWL	Industrial Waste Lagoon
µg/L	Micrograms per liter
O&M	Operation and maintenance
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TEAD	Tooele Army Depot
UDEQ	Utah Department of Environmental Quality
USACE	U.S. Army Corps of Engineers

1.0 INTRODUCTION

This Project Work Plan describes a general approach for gathering and analyzing the information needed to assess and implement alternative corrective measures at Solid Waste Management Unit (SWMU) 2, the Industrial Waste Lagoon (IWL) Pump and Treat System, at Tooele Army Depot (TEAD), in Tooele, Utah. This plan has been prepared for TEAD and the U.S. Army Corps of Engineers – Sacramento (USACE-Sacramento) under contract DACW05-00-D-0010 Task Order 7: Implementation of Alternative Measures, Industrial Waste Lagoon, Pump and Treat System, Tooele Army Depot, Utah.

The effort for each task of the Implementation of Alternative Measures, IWL at TEAD is detailed in this Project Work Plan. The primary objective of the project is to conduct evaluations supporting an exit strategy for the existing groundwater pump and treat system, and to initiate an interim operation mode during which groundwater pumping is minimized or eliminated.

This Project Work Plan specifies the project staffing, schedule, methods, and models necessary to accomplish the following tasks:

- System Non-Operation Test Proposal
- Comprehensive Site Evaluation
- Field Test
- Groundwater Flow Model Evaluation
- Groundwater Flow and Transport Model Development
- Aquifer Testing

Each of these elements is described in this plan.

All work conducted for this project will be performed according to TEAD's February 2001 Post Closure Permit (<http://www.deq.state.ut.us/EQSHW/TEAD.htm>) under the Resource Conservation and Recovery Act (RCRA), TEAD's September 1991 Federal Facilities Agreement, the Comprehensive Environmental Restoration, Compensation, and Liability Act, and the Utah Hazardous Waste Management Rules, Section 315-101, as applicable. Work will also be performed in accordance with other

applicable Federal, State, and local regulations and guidance documents. The U.S. Environmental Protection Agency (EPA) and Utah Department of Environmental Quality (UDEQ) will perform regulatory oversight of the project.

1.1 TEAD AND SURROUNDINGS

TEAD was originally established in 1942 as the Tooele Ordnance Depot by the U.S. Army Ordnance Department; it was designated TEAD in August 1962. Originally, TEAD was a major ammunition storage and equipment maintenance facility that supported other U.S. Army installations throughout the western United States. The mission of maintaining and repairing equipment was discontinued in 1995. Currently, the missions of TEAD are:

- To receive, store, issue, and maintain and dispose of conventional munitions
- To provide installation support to attached organizations
- To operate other facilities as assigned.

Developed features at TEAD include igloos, magazines, administrative buildings, a maintenance area, military and civilian housing, roads, and vehicle storage hardstands and other allied infrastructure. In 1993, TEAD was placed on the list of facilities scheduled for realignment under the Base Realignment and Closure (BRAC) program. Realignment of much of the former maintenance area was completed in January 1998.

TEAD is located in the Tooele Valley in Tooele County, Utah, immediately west of the City of Tooele and approximately 30 miles southwest of Salt Lake City (Figure 1-1). The valley is bounded to the south by the Stockton Bar and South Mountain, to the north by Grantsville and the Great Salt Lake, to the east by Tooele and the Oquirrh Mountains, and to the west by the Stansbury Mountains.

The installation occupies approximately 23,630 acres; 1,700 acres (from an original 25,173) were transferred to the Tooele City Redevelopment Agency in December 1998 under the BRAC program. The area surrounding TEAD is largely undeveloped, except for the neighboring areas of Tooele, Grantsville, and Stockton. To the north of TEAD, the land is used primarily for pasture and cultivation and to the west and south for rangeland grazing.

The Depot is bounded on the north by State Highway 112, north of which are the Tooele County Landfill, a construction company, a sports complex, and undeveloped land. Grantsville is approximately 2 miles north of the northwestern corner of TEAD. The southeastern portion of the installation is bounded by State Highway 36. A right-of-way for the Union Pacific Railroad is located on the eastern side of TEAD, and scattered residential homes are located to the east of the right-of-way. Residential development within the City of Tooele abuts the eastern boundary of the Depot.

1.2 IWL HISTORY AND BACKGROUND

The IWL is located in the eastern portion of TEAD (Figure 1-2). It was an unlined 400- by 200-foot evaporation pond that received wastewater from various industrial operations via unlined conveyance ditches that tied into a main ditch. The lagoon was used for approximately 23 years, beginning in 1965, during which an average of more than 140,000 gallons of industrial wastewater and stormwater were discharged daily until November 8, 1988.

Wastewater generated by the boiler plant, metal parts cleaning and stripping, sandblasting, degreasing, steam cleaning, and dynamometer test cells flowed into the IWL via the unlined ditches. Analytical results of wastewater samples collected in 1982 indicated the presence of heavy metals, volatile organic compounds, cyanide, phenols, and explosives (JMM, 1986a; 1986b). The subsurface soil and sludge were determined to contain numerous contaminants thought to have originated in the wastewater stream.

A two-stage cleanup for closure of the ditches and lagoon was completed in 1989. The cleanup consisted of the removal of contaminated soil from the ditches and its placement in the lagoon. The ditches were then lined with an impermeable synthetic liner and then backfilled with clean soil. The lagoon was capped with clay, a synthetic liner, and clean soil. Both areas were revegetated. The lagoon and primary ditch were fenced and posted with signs designating the area as a hazardous waste site.

A smaller cleanup activity occurred as part of construction of the Consolidated Maintenance Facility in 1988. Soil was removed from 650-foot segments of two ditches to a depth of approximately 12 feet and disposed of at the IWL (Tooele Army Depot, 1996). The State of Utah confirmed completion of the clean-closure of the two ditch

segments in a memorandum to TEAD dated May 5, 1989 (Utah Department of Health, 1989). After cleanup, the remediated ditches of the IWL were re-evaluated for their potential risks to human health and the environment. A risk assessment for the portion of the ditches within the BRAC parcel determined that the soil above and below the liner poses no unacceptable risk or hazard to human or ecological receptors. The soil at the lagoons and the main ditch (on Depot) need to be maintained as detailed in the closure of that site.

1.3 IWL PLUME

Contaminants discharged to the IWL have infiltrated to groundwater and contributed to an extensive northward trending dilute plume (Figure 1-3). The long axis of the plume runs parallel to the groundwater flow direction, and is approximately 22,500 feet in length as defined by a 5 microgram per liter ($\mu\text{g/L}$) contour. The plume is approximately 7,500 feet wide, defined by a 5 $\mu\text{g/L}$ contour to the west and an assumed boundary to the east. The eastern extent is assumed because it has commingled with a second plume identified as the Northeast Boundary Trichloroethene (TCE) Plume. The size and shape of the plume have varied over time due to fluctuations in concentrations detected in wells near the perimeter and to differing interpretation by various investigators. The plume and isoconcentration lines have been generally stable and have not shown a significant change subsequent to the construction of the pump and treat system (Figure 1-4).

The groundwater plume is predominantly TCE, although other organic chemicals have also been detected in the groundwater. These include carbon tetrachloride, chloroform, benzene, ethylbenzene, toluene, 1,1-dichloroethane, and 1,1-dichloroethene, 1,2-dichloroethane, 1,1,1-trichloroethane.

The IWL plume originates in the southwestern portion of Tooele Army Depot's former Industrial Area. This area is no longer owned by the U.S. Army, as it was transferred under BRAC. A significant source of contamination was the IWL and a series of wastewater collection ditches that were used until 1988. Other potential source areas of groundwater contamination upgradient from the IWL and ditches have been identified in the former Industrial Area; and these are under investigation as part of a

RCRA Phase II Facility Investigation (RFI), which is being performed concurrently with the Alternatives Measures Evaluation.

In 1993 Tooele Army Depot began operation of an 8,000-gallon per minute (gpm) groundwater treatment system designed to contain and remediate the SWMU 2 contaminated groundwater plume originating from the IWL. The groundwater treatment system consists of 16 extraction wells, influent conveyance piping, treatment system, effluent conveyance piping, and 13 injection wells. A 50,000-gallon aboveground tank receives contaminated groundwater from 16 extraction wells via the influent piping system. Three 75-horsepower (hp) pumps transfer contaminated water from the holding tank to two air stripping towers. Each of the transfer pumps has a 4,000-gpm capacity (half of the design capacity). During normal operations, only two pumps are operational, while the third is held in reserve for backup purposes. Three 50-hp blowers generate the required vertical airflow in the stripping towers. Like the transfer pumps, each blower is designed for one-half of the design system load, with two operating under normal conditions, and one held in reserve.

The treated water is conveyed from the stripping towers and flows by gravity through the effluent conveyance piping to the 13 injection wells. The alignment of the extraction wells is generally along the main axis of the plume and the groundwater flow direction. The 13 injection wells are located in an arc at the down-gradient leading edge of the plume. The injection wells were designed and located with the intent of controlling down-gradient migration of the plume. The system is operated continuously, and is staffed full time. The electric power cost approaches \$500,000 per year if all wells are operating.

The groundwater treatment system operates in accordance with requirements of the Tooele Army Depot Post Closure Permit. This permit includes requirements for operation, maintenance, monitoring, reporting, and aquifer protection goals. A requirement of the permit is to model the groundwater plume and provide an annual recalibration of the model. Operation of the groundwater treatment system in its current configuration is a permit requirement. Currently, the permit sets the aquifer protection standards that the system must eventually meet at EPA's maximum contaminant levels

(MCLs). There are, however, provisions in the permit for requesting modifications to the aquifer protection standards.

Despite the treatment of over 30 billion gallons of contaminated groundwater to non-detectable levels of contamination, the mass removal of contaminants, and a reduction in TCE concentrations in extraction wells and system influent, neither the concentrations in the groundwater plume, nor the aerial extent of the plume appear to have changed significantly. It has been reported that approximately 2,178 kilograms of TCE have been removed since plant operations began (Kleinfelder, 2002).

The Army's position is that the pump and treat system may have changed localized areas of the plume but it has not affected the groundwater contaminant plume size and does not have any significant effect on contaminant concentrations within the plume. The plume may have reached equilibrium within the natural sub-surface system prior to the startup of the pump and treat system. Natural attenuation may be reducing the concentration of TCE in the plume at the down-gradient, leading edge of the plume today, and may have been occurring prior to the system startup in 1993. Due to the nature of previous investigations and the decision to construct the pump and treat system, the stability of the plume was not evaluated prior to active remediation, nor were alternatives other than pump and treat considered.

Accordingly, TEAD intends to implement an alternative remedy that manages groundwater contamination through institutional controls, monitored natural attenuation, and *in situ* source control where such technologies are cost-effective. A thorough evaluation of the effectiveness of the existing groundwater treatment system is necessary to support an exit strategy for the system and to provide support for future development of a monitored natural attenuation remedy for groundwater. Natural attenuation mechanisms will be reviewed during the comprehensive evaluation.

In addition to the preparation of this work plan, the evaluation consists of tasks discussed with UDEQ, EPA, and US Army stakeholders at a meeting held at TEAD on May 15, 2002 (meeting minutes available from USACE, upon request). These tasks encompass:

- A comprehensive review of all existing and relevant data to obtain a thorough understanding of the site geology and hydrogeology, and to clearly identify the effect of the system on the groundwater plume.
- A determination of the impact of pumping and injection by observing aquifer's rebound response after shutting down the treatment system.
- An assessment of whether the existing system is capable of meeting the established objective of reducing concentrations of contaminants in groundwater to MCLs.
- Assisting in the development of the existing groundwater model to include a transport component that can be used to evaluate a monitored natural attenuation remedy for groundwater.

2.0 SYSTEM NON-OPERATION TEST PROPOSAL

TEAD will prepare a Test Proposal to UDEQ recommending to completely or partially shut off the pump and treat system, and to evaluate the effects of this action on the aquifer and the groundwater plume. The purpose of the proposed test is to obtain information needed to assess whether the existing groundwater treatment system has had, and the degree to which it can have, an effect on the extent of the groundwater plume and measured levels of contamination. The proposal will conform to requirements of TEAD's Permit under the UDEQ-Department of Solid and Hazardous Waste (DSHW). The proposal will state that the evaluation period will extend for 3 years, during which time the aquifer and contaminant behavior will be studied.

The System Test Proposal will include the following major elements:

- A Monitoring Plan to measure changes in hydraulic gradient, water level, and contaminant concentration in the aquifer during the test;
- An Alternative Pumping Strategy to instigate extraction again should contaminant concentrations increase at critical locations within the plume;
- A System Maintenance Plan to identify requirements for maintaining the pump and treat system equipment during the test.

Remedial system engineers and hydrogeologists will complete this proposal based on knowledge of the SWMU 2 hydrogeology, of the historical record of the nature and extent of groundwater contamination, and of the current pump and treat system design and operation. Data pertaining to the hydrogeology and groundwater plume will be obtained from various sources, including the online TEAD database, and previous technical reports. The operation and maintenance (O&M) contractor (PSG) will provide a copy of an up-to-date O&M Plan or relevant sections of the plan, selected system design drawings, and detailed requirements for system maintenance. This includes the age, usage, condition, and expected life-cycle of the equipment. In the Test Proposal, the O&M contractor's tasks for maintaining the equipment in working condition will be detailed.

As the system is shut down, groundwater elevations and the magnitude and directions of hydraulic gradients in the aquifer are expected to rebound to reflect the

natural state of the aquifer, although these quantities may continue to be influenced by activities off TEAD property. Measured contaminant concentrations are also expected to change, perhaps on a different time-scale than changes in physical characteristics of the aquifer. A thorough analysis of hydrologic and chemical data gathered during and after the rebound will enable a thorough understanding of the aquifer under non-pumping conditions, and will also provide information regarding aquifer properties. For example, the storage properties of the aquifer, as determined from matching rebound curves of a previously pumped well, can be used in combination with hydraulic conductivity to determine diffusivity. Such data can be used to assess the quality of previously conducted aquifer tests in the well. With regard to groundwater contamination, installation of monitoring wells has continued since the pump and treat system began operation, resulting in an enhanced spatial network of wells covering the extent of the contaminant plume. Some suggest that the plume may have reached equilibrium within the natural sub-surface system prior to the startup of the pump and treat system. Chemical data gathered from selected wells in the network provide the basis for evaluating the hypothesis that the TCE plume may have been in a steady-state prior to pumping, which will be addressed during the evaluation of the test. These data collection steps will be detailed in the Monitoring Plan. The Monitoring Plan will identify

- The order in which extraction wells will be shutdown to avoid interferences,
- The wells to be monitored for water level elevation and chemical rebound,
- The criteria used to select each well,
- The type, method, and frequency of measurements to be made in each identified well, and
- Whether monitoring of the well will continue after an initial rebound period.

In addition, the Monitoring Plan will specify the techniques to be used to assess whether significant changes have occurred in the monitored quantities.

The timely detection of significant increases in contaminant concentrations is particularly crucial, because of the potential for contaminants to migrate beyond controlled areas during the non-pumping period. Consequently, the Test Proposal will examine and describe alternate, interim pumping strategies to address these

circumstances should they arise. In particular, the Alternative Pumping Strategy, in conjunction with the Monitoring Plan, will identify *sentinel* wells in sensitive locations that will provide information on the location and behavior of contamination within the aquifer while the treatment system is shut down. Based on the analysis of monitoring results, pumping may need to restart in certain areas to remain in compliance with the permit. The decision mechanism for restarting pumping, which may employ statistical procedures, will be detailed in the Alternative Pumping Strategy. Under present consideration are statistical procedures to test whether current data are consistent with past data (Gilbert 1987; Gibbons 1994), and other analysis to detect trends in data (Gilbert 1987). Trend testing will be performed on data collected following shutdown of the treatment system. Pre-shutdown data will be used as a baseline, not in trend testing.

Restarting of pumping in a well or wells, either to exert hydraulic control on contaminant migration or for maintenance reasons, is a potential opportunity to obtain additional information on aquifer properties. The Monitoring Plan and Alternative Pumping Strategy will detail how to exploit these opportunities.

Finally, the System Maintenance Plan will identify the necessary steps to safely maintain the pumps and treatment facility in working order. The plan will explicitly identify mothballing tasks for equipment, and describe a maintenance schedule for lubrication, occasional operation and other activities required to keep the treatment system ready for possible future operation.

The Test Proposal will be submitted to UDEQ for review and approval prior to the onset of any of the activities detailed in the proposal. Document submittals are more thoroughly addressed in Section 8, Schedule.

3.0 COMPREHENSIVE EVALUATION

Although the groundwater plume from the IWL has been the subject of considerable work at TEAD, the area would benefit from a detailed evaluation of geologic and hydrogeologic properties of the site. This comprehensive evaluation of geologic information will add to the previous geologic and hydrogeologic assessments. The goal is to produce the best possible understanding of the fundamental processes of contaminant migration at the site to support future remedial decisions. The intention is that all relevant and meaningful scientific lines of evidence will be considered as a part of identifying a site conceptual model. This evaluation would also serve to validate the site groundwater fate and transport model.

All historic groundwater data, lithologic data, and pump and treat operational data will be synthesized by geologists and hydrogeologists. The following information will be gathered into the evaluation:

- Geologic data - borehole logging, geophysics, soil properties, literature review
- Hydrogeologic data – evapotranspiration, non-precipitation sources of infiltrating water, groundwater pump tests, geochemistry, contaminant distribution, flow direction and velocity, vertical gradients, thermal zones
- Chemical data – groundwater contaminant vertical and horizontal distribution, changes with time, natural attenuation parameters, contamination mass, mass removal associated with the pump and treat system
- Pump and treat system – mass removal efficiency, well radius of influence, effects on groundwater elevation, horizontal and vertical placement relative to contaminant sources.

The site information will be used to develop a scientifically sound revised site conceptual model. The strength of a model based on such a comprehensive evaluation is that it reduces the uncertainties in selecting a remedial alternative at the IWL, thereby reducing costs while maintaining protection of human health and the environment.

USACE-Sacramento has expended considerable effort amassing the geologic, hydrogeologic, and chemical data into a database. This database provides the primary basis of information gathering for this task. In addition, data from the pump and treat

system operation (e.g., gallons treated) will be incorporated into the evaluation. The thickness of penetration of wells into the contaminated zone, as well as the screened interval of wells will be of particular concern.

In addition to the internet database developed by Synectics, technical literature regarding site geologic setting, history, and conditions will be researched. These efforts will rely on peer-reviewed journal-quality sources including those from the U.S. Geological Survey or local universities. These sources will be used to evaluate whether sufficient data are extant for identifying low permeability zones, water quality, or other hydrogeologic information relevant to groundwater flow, use, and protection in the local area. The geologic history of Pleistocene Lake Bonneville and its depositional environment will be evaluated for its significance to the current hydrogeologic condition at the site. Surface topography and geophysical data shall be evaluated for any inferences that can be made with respect to depositional environment and resulting hydrogeologic behavior.

Using historic modeling efforts at this stage of the program, TEAD will estimate cleanup time and cost of operating the current treatment system until completion of cleanup. Studies sponsored by the U.S. Department of Defense Environmental Security Technology Certification Program and revised by GeoTrans will form the basis for this effort; additionally, a transport model is currently under development by the USACE Hydrologic Engineering Center (HEC). The current transport model developed by HEC and GeoTrans will be modified in subsequent versions to reflect the results of the Non-Operation Test and Comprehensive Evaluation, and to account for source terms determined in the SWMU 58 source area investigations.

Where appropriate, three-dimensional information will be incorporated into a 3D visualization scheme for presentation of fundamental hydrogeologic relationships. Where sufficient data are available, changes in groundwater contamination, temperature, and gradient will be expressed in time-lapse or animated fashions. The software applications used for these demonstrations are expected to be GMS and Groundwater Vistas for lithology and groundwater modeling and EVS for 3D presentation and animation.

The results of this evaluation will be presented in the Comprehensive Evaluation Report, which will be submitted to UDEQ for review. Document submittals are more thoroughly addressed in Section 8, Schedule.

Where reinterpretation of previously conducted aquifer tests is required, methods appropriate to an unconfined aquifer will be used. These methods will be applied uniformly to each of the pump tests in conformance with the recommendations in American Standard Test Method (ASTM) D4043 and methods referenced in that standard (ASTM, 2002).

4.0 COMPREHENSIVE EVALUATION OF SYSTEM, FIELD TEST

The shutdown of the existing pump and treat system is an excellent opportunity to measure aquifer characteristics. During the 3 years of testing, TEAD will continue the routine collection of groundwater samples and water level measurements presently performed on a semiannual basis.

In addition, field measurements (e.g., rebounding water levels) will be collected logarithmically up to 15 minutes, and then every 30 minutes for the first month of reduced operation. Water levels will continue to be closely monitored at each extraction well for the duration of the test. Wells slated for rebound measurements will be defined in the Test Proposal, which will also include sampling protocols for the wells. TEAD expects that wells within the areas of greatest drawdown and those within the bedrock block will be subject to frequent water level measurements of rebound rates using continuously operating pressure transducers. Local public wells will also be used as available. Rebound is best measured in non-pumping wells. During that time, an experienced hydrogeologist will be on-site to observe and counsel in the data acquisition. In addition, UDEQ is urged to participate in close observation of the rebound measurements. As appropriate, changes in the field collection of data may be possible during this period of aquifer rebound.

The groundwater in the area of the plume will be monitored for 3 years according to the protocols identified in the Test Proposal. At this time, TEAD plans to collect both chemical and hydrologic data during the 3-year period at a frequency of at least twice annually. (This is in addition to the initial intense rebound data collection period.)

After 3 years of semiannual data review, TEAD will submit a brief technical memorandum summarizing the evaluation. TEAD expects the technical memorandum to include:

- Chronology of any interim pumping events,
- Water level data,
- Sampling and analysis data,
- Assessment of aquifer behavior,
- Assessment of plume behavior, and

- Results of aquifer tests.

The review of the first set of rebound data is likely to necessitate additional aquifer testing.

UDEQ will review the technical memorandum. Document submittals are more thoroughly addressed in Section 8, Schedule.

5.0 GROUNDWATER FLOW MODEL EVALUATION

The current TEAD groundwater model, which is calibrated annually in accordance with the Post Closure Permit, will be reviewed on the basis of the new geologic information supplied by the Comprehensive Evaluation. Workers at USACE HEC have added a transport component to the existing flow model; enhancement of the transport model is now underway at USACE HEC and is expected to be completed within the time frame of this project. The lead HEC modeler will present the latest flow and transport models to UDEQ for review. In addition, TEAD will promote a cooperative review of the model by the hydrogeologists and groundwater modelers who develop the Comprehensive Evaluation. This will provide an objective third party evaluation of the HEC model, and incorporate the latest site knowledge into the modeling program. The third party evaluation will be performed by URS groundwater modelers.

To perform this task, electronic copies of the computer files that constitute the existing model will be loaded into either or both of the GMS or Groundwater Vistas software platforms, and the model structure, parameterization, and performance will be reviewed by the third party. To assess the consistency between site hydrogeology and the current model the following will be evaluated:

- Areal extent of the modeling domain,
- Discretization of the modeling domain into a computational grid ((x,y) grid, layers in z),
- Consistency of the layer definitions with the known hydrogeology and vertical distribution of aquifer properties,
- Specification of boundary conditions,
- Specification of sources and sinks, including recharge and evapotranspiration,
- Spatial distribution of aquifer properties,
- Impact of re-evaluated aquifer tests, and
- Ability of model to match spatial and temporal observations.

The review will particularly focus on the ability of the flow model to simulate the observed response of the aquifer to the shutdown of the groundwater treatment system by comparing simulation projections to the test field data.

Because of the size of the site, knowledge of the subsurface will always be sparse, regardless of the data provided by past, ongoing, and future investigations. Assumptions and their resulting uncertainty are thus inherent characteristics of a numerical representation of the natural aquifer system. The groundwater model review will examine the consequences on remediation projections of this uncertainty by conducting a targeted set of sensitivity analyses. These analyses will be performed by considering the extrema of a plausible range of magnitude for an aquifer property. Sensitivity studies will be performed both on individual aquifer characteristics, and on combinations of characteristics, to investigate the range of uncertainty in simulation outcomes due to ambiguous knowledge of aquifer properties. This approach allows the impact of uncertainty to be estimated without resorting to a fully stochastic approach in which permeability, and possibly other aquifer characteristics, is regarded as a spatial random function or random variables, and uncertainty is assessed using the Monte Carlo method. To maximize collaboration with stakeholders, TEAD's modelers will discuss the uncertainty approach with regulators during regular meetings or teleconferences.

TEAD will present the model evaluation and recommendations in the form of a Technical Memorandum to UDEQ. (Document submittals are more thoroughly addressed in Section 8, Schedule.) This memorandum will include visualizations of site hydrogeology, distribution of aquifer properties, and animations of the temporal behavior of the system. To the extent allowed by schedule, it will include insight obtained from the reduced operation test and re-evaluation of previously conducted aquifer tests.

This evaluation of the model will not supplant fulfillment of the Part B Permit requirement; TEAD anticipates that this will continue to be performed by HEC at this stage.

6.0 FLOW AND TRANSPORT MODEL DEVELOPMENT

TEAD will develop a modified groundwater flow model to accommodate transport modeling; HEC will lead this task, but be provided support by URS. The recommended changes are expected to result from activities performed in preceding tasks of this effort, especially the comprehensive data review and the evaluation of the current groundwater model. The flow and transport model is ultimately expected to aid the development of an appropriate set of likely corrective measures for chlorinated organics in groundwater at the Depot.

As part of this task, TEAD will conduct sensitivity studies of transport and natural attenuation parameters, using the groundwater flow field generated by the current groundwater flow model, as modified by the previous task (Model Evaluation). The results of these studies will be used to suggest possible modifications to the groundwater flow model needed to accommodate simulation of transport, and to provide a general assessment of bounds on transport model parameters.

Methods that may be used to develop recommendations to HEC include particle tracking, simulation contaminant concentration based solely on advective and dispersive transport, and simulation of contaminant concentration based on advection, dispersion, and natural attenuation. Forward particle tracking provides insight to the pathways followed by releases from known and suspected sources. It can be used with a flow field reflecting the natural state of the aquifer system, and another reflecting the operation of groundwater treatment system, to aid in evaluating the effectiveness of the treatment system. Indeed, any combination of extraction and injection wells can be studied, including hypothetical wells. Backward particle tracking will be used with a flow field obtained from simulating full operation of the existing groundwater treatment system to estimate the capture zone of the pumping wells in the treatment system. Simulation of advective/dispersive transport and natural attenuation will yield estimates of the distribution of contaminant concentrations in the aquifer system. Similar to the previously mentioned particle tracking studies, transport and attenuation will be examined under multiple operating scenarios for the treatment system.

Sequential sensitivity studies will be conducted to understand the effect of transport and attenuation parameters, individually and collectively, and under various operating scenarios for the groundwater treatment system. The uncertainty will be estimated as described above: by considering the extreme of a plausible range of parameter values. An outgrowth of this activity, in combination with the data review, will be to identify what additional data may be needed to successfully conduct future contaminant transport and attenuation studies.

TEAD anticipates that there will be considerable ongoing dialogue between HEC, contractors, and the UDEQ as the model is developed. The results of the transport model will be provided in a public presentation to UDEQ. This will provide an opportunity for technical discussions of the model input and results.

7.0 AQUIFER TESTING

This task will be exercised once the team identifies a need for additional aquifer testing during the test period. The working group anticipates that TEAD will need to develop a proposal identifying aquifer data gaps following the gathering of the test data. These may include the need for pump tests, slug tests, or other types of hydrogeologic information to better understand all areas of groundwater behavior within the plume and affected areas. Moreover, as described in Section 2.0, restarting of pumping to exert control on contaminant migration or for maintenance purposes may provide additional opportunities for aquifer testing.

It is premature to suggest plan contents, as the data gaps will not be known until the completion of the test program. Once developed, the plan will undergo regulatory review.

8.0 SCHEDULE

The proposed efforts in this Project Work Plan are expected to be accomplished in nearly 3 years. The following table summarizes key dates for the proposed documents and milestones.

Task Duration (days)	Task	Scheduled Due Date
60	Draft System Test Proposal	6/1/03
21	Government comments received	6/22/03
21	Draft-Final System Test Proposal	7/12/03
45	Regulatory comments received	8/13/03
21	Final System Test Proposal	9/3/03
120	Draft Comprehensive Evaluation Report and Model Technical Memorandum	8/1/03
21	Government comments received	8/23/03
21	Draft-Final Comprehensive Evaluation Report and Model Technical Memorandum	9/11/03
45	Regulatory comments received	11/12/03
21	Final Comprehensive Evaluation Report and Model Technical Memorandum	12/6/03
730	Begin System Non-Operation Field Test*	12/6/03
30	Draft System Test Technical Memorandum	2/13/06
21	Government comments received	3/14/06
21	Draft-Final System Test Technical Memorandum	4/12/06
45	Regulatory comments received	6/11/06
21	Final System Test Technical Memorandum	7/10/06

*Plan to begin testing immediately following semiannual monitoring event, if possible.

Only tasks specific to this Work Plan are shown above, Phase II RFI and other related tasks are not shown here.

The documents shall be distributed as outlined in the following table:

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*electronic copy (as PDF) will be submitted

9.0 REFERENCES

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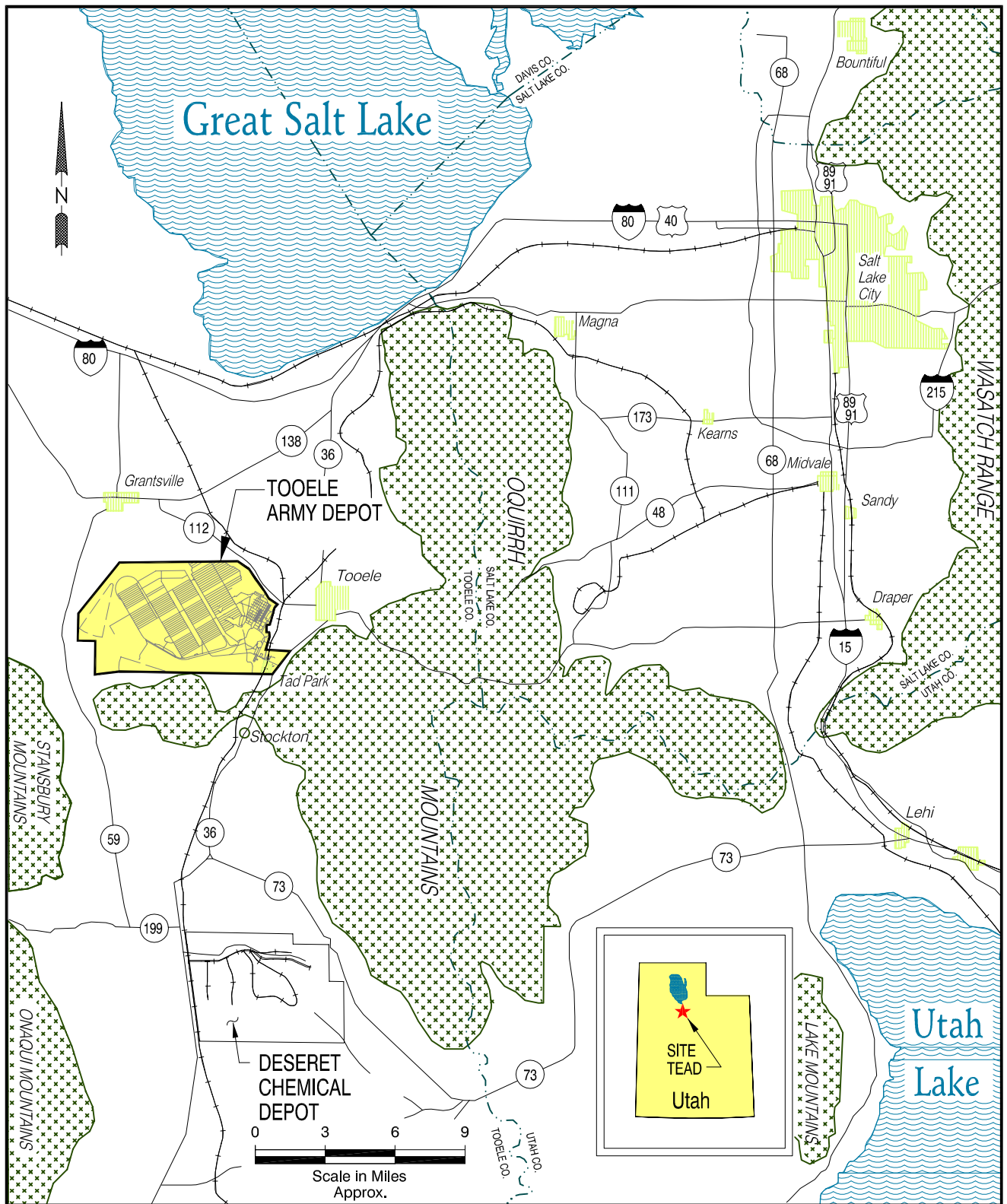


FIGURE 1-1
LOCATION MAP OF
TOOELE ARMY DEPOT
AND VICINITY

